Industrial Clustering, Knowledge Interaction, and Product Innovation in the Thai Food Processing Industry

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ABSTRACT

This study examines the effects of industrial cluster's contextual factors (i.e. localization economies and competitive pressure) and knowledge interaction on two types of product innovation – new product development (NPD) and product modification (PMOD), using the establishment-level data of food processing industry in Thailand. The key results show that the cluster's labor market pooling and competitive pressure are two contextual factors determining the innovative capability of food processing establishments; however, while the former is conducive to both NPD and PMOD, the latter exerts a positive and significant impact on NPD only. Knowledge interaction with universities and research institutes in the cluster has a positive effect on NPD, while interactions with other actors (i.e. suppliers, customers, business service firms, and governmental agencies) do not benefit establishments' product innovation. The results are discussed in connection with policy implications for promoting innovation in food processing industry in Thailand.

Keywords: Product Innovation, Industrial Clustering, Knowledge Interaction, Thai Food Industry

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บทคัดย่อ

บทความชิ้นนี้ใช้ข้อมูลระดับสถานประกอบการในอุตสาหกรรมอาหารแปรรูป เพื่อวิเคราะห์ผลกระทบของปัจจัยในเชิงบริบทของคลัสเตอร์อุตสาหกรรม (การประหยัดจากความเชี่ยวชาญของท้องถิ่นและแรงกดดันทางการแข่งขัน) และการปฏิสัมพันธ์ในเชิงความรู้ที่มีต่อนวัตกรรมผลิตภัณฑ์สองประเภทคือ พัฒนาผลิตภัณฑ์ใหม่และการปรับปรุงผลิตภัณฑ์เดิม ผลการศึกษาพบว่าการมีตลาดแรงงานขนาดใหญ่และการแข่งขันระหว่างสถานประกอบการภายในคลัสเตอร์เป็นสองปัจจัยเชิงบริบทที่ส่งผลต่อนวัตกรรมผลิตภัณฑ์ โดยที่ตลาดแรงงานขนาดใหญ่ส่งผลดีทั้งในแง่ของการพัฒนาผลิตภัณฑ์ใหม่และการปรับปรุงผลิตภัณฑ์เดิม ส่วนการแข่งขันส่งผลดีเฉพาะต่อการพัฒนาผลิตภัณฑ์ ปฏิสัมพันธ์กับมหาวิทยาลัยและสถาบันวิจัยภายในคลัสเตอร์ส่งผลบวกต่อการพัฒนาผลิตภัณฑ์ใหม่ ในขณะที่ปฏิสัมพันธ์กับตัวแสดงอื่น ๆ (ได้แก่ ซัพพลายเออร์ ลูกค้า บริษัทผู้ให้บริการทางธุรกิจ และองค์กรของรัฐ) ไม่ได้ให้ประโยชน์ในด้านการพัฒนานวัตกรรมผลิตภัณฑ์ใด ๆ งานวิจัยนี้อภิปรายผลพร้อมทั้งเสนอนัยยะเชิงนโยบายสำหรับการส่งเสริมการพัฒนานวัตกรรมในอุตสาหกรรมอาหารแปรรูปของไทย

คำสำคัญ : นวัตกรรมผลิตภัณฑ์ คลัสเตอร์อุตสาหกรรม การปฏิสัมพันธ์ในเชิงความรู้ อุตสาหกรรมอาหารของไทย

1. INTRODUCTION

The industrial clustering is widely regarded among scholars and policy makers as an important way to foster firms' innovative capabilities. The cluster-based industrial development strategy, which is built on the advantages of spatial proximity and networking among firms and related organizations, has been implemented in many countries over the past two decades. The core idea behind the concept of industrial clustering is that firms can draw benefits from knowledge spillovers and information sharing in their location where other related firms and organizations are present, and networks among them are created (Porter, 1998).

In Thailand, the government has adopted a cluster-based industrial development strategy aiming to encourage collaborations and information sharing among co-located firms and supporting institutions. Since the early 2000s, industrial cluster strategy has been implemented, and several initiatives have been launched (Wonglimpiyarat, 2006; MOI, 2011). In the food processing sector, cluster-based initiatives have been known in various names including the Thailand Food Cluster, Thailand Food Valley, and Food Innopolis (NSTI, 2014). Recent years have witnessed some changes in the Thai government's industrial promotion policies toward cluster-based supports.[1] However, despite the adoption of the cluster-based industrial development strategy, there has been no effort to date to investigate the effect of industrial clustering on firms' innovation in the Thai food processing industry.

This study aims to provide an academic contribution to the existing knowledge regarding the effect of industrial clustering on firms' innovative capabilities. There are two notable gaps in the literature that this paper aims to fill. First, there has been a long debate in the literature concerning the mechanisms through which spatial clustering may generate positive effects on firms' innovation. While some researchers believe that firms can benefit from the so-called localization economies (i.e. labor market pooling, supplier concentration, and knowledge spillovers) (Jaffe, Trajtenberg, & Henderson, 1993; Giuliani, 2007; Bonte, 2008), others argue that it is the network and purposeful knowledge interaction among knowledge actors in the cluster that is more relevant (Breschi & Malerba, 2005). To date, this debate is still unresolved, and the current study aims to engage in the debate by separately examining the effects on the firm's innovation of localization economies and knowledge interaction. The separation of these two elements is also relevant for a practical reason because it allows us to see how each mechanism contributes to the innovativeness of firms so that policy implications can be drawn accordingly on the relative importance of such mechanism. Second, this study can also

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[1] One instance is the change in Board of Investment's (BOI) investment promotion policy in which investment incentives have been shifted from the zone-based and broad-based supports to the cluster-based supports. Considerable incentives (both tax and non-tax ones) are now given to the investment projects that fall into the government-defined strategic clusters. In the case of food processing, strategic clusters are defined by the location of food products (BOI, n.d.).

contribute to the knowledge gap in Thailand by investigating the role of industrial clustering in promoting the innovation of firms in the Thai food sector. The existing studies that attempt to explain the factors affecting Thai food firms' innovation fall into two main groups: one group examining innovation from the perspective of the *resource-based view* (Siriwongwilaichart & Winger, 2004; Dhammavithee, Shankar, Jangchud, & Wuttijumnong, 2005; Huq & Toyama, 2006), and the other group from the *organizational management perspective* (Suwannaporn & Speece, 1998, 2000, & 2010). These studies focus exclusively on firm-specific resources and their organizational managements with no attention paid to the immediate location in which firms are situated (or the industrial cluster). To my knowledge, this study is the first to examine the effect of industrial clustering on the innovative capabilities of the Thai food firms. Here, I pose the research question as follows: *how localization economies and knowledge interaction in the industrial cluster affect Thai food processing firms' product innovation?*

Apart from academic contribution, this study also has practical and policy contributions. It is widely known that the food industry is very important for the economic development of Thailand. For instance, this industry accounted for 10.5% (1.35 trillion baht) of Thailand's GDP and generated 12.7 jobs in 2014 (Kasikornthai Research Center, 2015). The value of food export in the same year was 915.32 billion baht (NFI, 2017), accounting for 12.5%[2] of the country's total export. Despite its importance, Thai food industry is currently facing competitive pressures. Competition in both domestic and international market is intense, particularly from lower-cost competitors (e.g. Vietnam, Indonesia, and China) (Intarakumnerd et al., 2015); this poses a risk of losing the competitiveness if Thai food producers are still unable to drive their competitive advantage based on the high value-added operation. Although some food firms have acquired capabilities to manage their brands and even become the main players in the regional and global markets, the vast majority of Thai food producers are still small enterprises lacking technological and innovative capabilities (Saigosoom, 2012). Therefore, investigating whether and how localization economies and knowledge interaction enhance innovation in food processing industry is of policy as well as practical relevance.

The rest of this paper is organized as follows. Section 2 provides a review of the theoretical and empirical literature regarding the role of industrial clustering as well as firm characteristics and resources that may affect the firm's innovative capabilities. This section also states hypotheses to be tested. Section 3 discusses the data collection, variable construction, and analysis method. Section 4 reports and discusses the results. The last section makes a conclusion and describes some limitation of this study.

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[2] Author's calculation based on the data on food export from the NFI and total export from the Ministry of Commerce.

2. LITERATURE REVIEW AND HYPOTHESES

2.1 Localization Economies and Competition

Industrial clusters can be defined as "…geographic concentrations of interconnected companies and institutions in a particular field" (Porter, 1998, p.78). The industrial cluster literature argues that a cluster can benefit firms' innovativeness mainly due to knowledge externalities. Central to this argument is that a spatial proximity between firms and related organizations facilitates the localized knowledge spillovers (LKS), which is the flow of knowledge, especially tacit knowledge, that is likely to happen in a confined space (Rodriguez-Pose & Comptour, 2012). Tacit knowledge is embedded in a person and difficult to codify; thus it is more efficient to transfer in a short distance using face-to-face interactions (Howells, 2002). Some empirical studies (e.g. Jaffe et al., 1993; Fritsch & Franke, 2004; Grillitsch & Nilsson, 2015) find evidence to support this argument and show that knowledge for innovation tends to diffuse in the local setting and tends to lose its significance in greater distance.

Some researchers investigate the mechanisms through which LKS takes place. One group of literature explains the mechanism of LKS from the perspective of labor market pooling and demonstrates that LKS can be facilitated by labor mobility, resulting in skilled workers bringing with them knowledge from one firm to other firms (Boschma, Eriksson, & Lingren, 2008). Also, in a cluster that individual workers establish strong network ties, informal interactions among them can facilitate the transmission of knowledge (Saxenian, 1994). This generates a local "buzz" in which knowledge is spontaneously shared among firms and people in the same local setting (Bathelt, Malmberg, & Maskell, 2004). The other group of literature emphasizes the importance of the supplier-buyer relations in industrial clusters as another mechanism of knowledge spillover (Porter, 1998, 2000; Giuliani, 2007). In a cluster where suppliers are concentrated around the core firm, the exchange of information and knowledge spillover occur (Porter, 1998; Bonte, 2008). Theoretically, the labor market pooling and supplier concentration constitute the so-called localization economies which are the main cause of knowledge spillovers and innovativeness of firms in the cluster.

Not only can clusters benefit firms' innovativeness via localization economies, but it also can exert the influence on innovation through localized competition. Porter (1998, 2000) argues that the co-location with their rivals gives firms competitive pressures to innovate. In a cluster, not only firms can easily monitor their rivals, but rivals can also monitor them (Porter, 1998). Despite strong theoretical ground, empirical evidence of competitive pressure on innovation is mixed. For example, Bengtsson & Solvell (2004) find positive effects of localized completion on firms' and regional innovations, while Plummer & Acs (2014) find negative effects and argue for a monopolistic structure of the local industry to drive innovations.

Based on the literature on localization economies and competitive pressure reviewed above, we can state the hypotheses as follows:

Hypothesis 1a – the localization economies in terms of labor market pooling have a positive effect on food processing establishments' product innovation.

Hypothesis 1b – the localization economies in terms of supplier concentration have a positive effect on food processing establishments' product innovation.

Hypothesis 1c – the localization economies in terms of knowledge spillover have a positive effect on food processing establishments' product innovation.

Hypothesis 1d – competition among food processing establishments in the cluster has a positive effect on an establishment's product innovation.

2.2 Knowledge Interaction

The notion of LKS has been criticized for its conceptual vagueness and measurement problems (Breschi & Lissoni, 2001). Empirical literature that sees a positive impact of clustering and knowledge spillovers on firms' innovation tend to suffer a methodological problem in being unable to distinguish the effects of involuntary spillovers from those of interactive or collaborative transfer of knowledge. Some researchers have examined the role of localized networks in facilitating interactive learning and innovation in the local industry (e.g. Breschi & Malerba, 2005). A variety of approaches has been developed to see how interactive learning facilitated by particular institutional settings in the locality may lead to innovation and growth. These approaches involve the *regional innovation* system approach (Doloreux, 2002; Asheim, Smith, & Oughton, 2011), the *innovative milieux* approach (Camagni, 1995), and the *localized learning* approach (Maskell & Malmberg, 1999). Despite some variation in conceptual basis, these approaches commonly regard innovation as an evolutionary process, which requires interactive learning and active participation in various types of knowledge networks (Breschi & Malerba, 2005). As differed from the LKS approach, the proponents of these approaches do not believe that the transfer of knowledge will take place involuntarily in the form of pure knowledge spillovers, nor firms can passively benefit from such spillovers by just locating in the cluster. Firms' innovation is an outcome of interaction with knowledge actors rather than involuntary knowledge spillovers.

The inter-firm linkage literature suggests that suppliers and customers are significant knowledge sources for innovation. According to Porter (1998), firms located in a strong industrial agglomeration can easily acquire knowledge and information from their suppliers and customers and use it as a complementary resource for enhancing their productivity and innovation. Interactions with customers enable firms to identify market demand and discover opportunities for innovation (Nazari-Shirkouhi, Keramati, & Rezaie, 2015). Communication with customers can reduce the time-to-market of new products (Feng, Sun, Zhu, & Sohal, 2012) and increase product features and quality (Bonner, 2010). Interactions with suppliers can benefit firms' innovation in many ways including the reduction of financial costs and time spent in the new product development (NPD) process, better and faster access to knowledge, and improvement in product quality (Johnsen, 2009). Apart from customers and suppliers, business service providers can serve as an important knowledge source for innovation. Business service providers encompass knowledge providers, capital providers, machine vendors, and logistics service firms. These service providers can play a significant role in upgrading regional innovation system in terms of knowledge creation, transformation, and diffusion (Muller & Zenker, 2001). Thus, it is possible to state the hypotheses on the importance of (market-based) knowledge interaction with each actor as follows:

Hypothesis 2a – knowledge interaction with suppliers in the cluster has a positive effect on establishments' product innovation.

Hypothesis 2b – knowledge interaction with customers in the cluster has a positive effect on establishments' product innovation.

Hypothesis 2c – knowledge interaction with business service providers in the cluster has a positive effect on establishments' product innovation.

Apart from inter-firm linkages, linkages with research organizations, on the one hand, and with government agencies, on the other hand, may also enhance to firms' innovation. According to Leydesdorff & Etzkowitz (1998), government and university constitute two core elements in the Triple-Helix model of university-industry-government relations. These elements mutually interact, coevolve, and play overlapping roles to boost up the innovation system of the country or region.[3] Universities and public research organizations (PROs) focus their research mainly on basic and applied sciences that are accessible with low costs (Fritsch & Schwirten, 1999). Interaction with universities and PROs enables firms to keep up with the frontier of scientific and technological knowledge in the field (Prahbu, 1999) and open up the opportunity that firms can integrate such knowledge into internal innovation process to generate commercial value (Fabrizio, 2006). As knowledge produced by universities and PROs is based on basic research and pure science, interaction with these organization can increase firms' ability to create a more rapid type of innovation (e.g. entirely new products) (Todtling, Lehner, & Kaufmann, 2009). Thus, it can be hypothesized as:

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[3] In the triple-helix model, universities assume the "third mission," in addition to teaching and research, which is related to undertaking an entrepreneurial role and transforming their scientific discoveries into the commercial and market values. Governments (national and regional ones), besides their traditional role as a regulator, undertakes the role of a venture capitalist and business incubator as well as providing necessary conditions to support effective interactions between university and industry (Etzkowitz & Leydesdorff, 1998).

Hypothesis 2d – knowledge interaction with universities and PROs in the cluster has a positive effect on establishments' product innovation.

Local governments and other kinds of governmental agencies in the region can also play a vital role in promoting regional innovation system. In many economically high performing regions (e.g. Baden-Wurttemberg, Emilia-Romagna, Wales), local government institutions help address market failures in the innovation system such as providing finance and loan guarantee for high-risk innovation projects or providing hard and soft infrastructure to support firms' innovative activities (Cooke, 2001). Also, local government can affect the success of R&D alliances by acting as an initiator, broker, and intermediary. Hsing, Teng, Yin, & Hsu (2013) suggests that, with local government's direct involvement, the learning capabilities of major partners involved in R&D alliances can be enhanced. Accordingly, we can state the hypothesis as:

Hypothesis 2e – knowledge interaction with governmental agencies in the cluster has a positive effect on establishments' product innovation.

2.3 Firm Characteristics and Resources

Some characteristics and resources of firms, including size, export, foreign ownership, research and development, and participation in global production networks, can affect their innovation performance. Firm size can positively impact firm innovation due to resource availability as well as scale economies effects (Jenssen & Nybakk, 2013). Size also symbolizes the market power of the firm which in turn exerts the influence on innovation via the monopolistic ability to appropriate the benefits arisen from new ideas (Nicholas, 2003). Export firms are under the competition pressure in the global market, forcing them to innovate to remain competitive (Criscuolo, Haskep, & Slaugher, 2010). They can also benefit from learning and information spillovers in the export market, which directly increases their innovative ability (Love & Ganotakis, 2013). Foreign ownership is also an important factor on firm innovation. Linkages with foreign companies via ownership structure open up the opportunity that local firms can acquire new knowledge and technology from abroad (Choi, Lee, & Williams, 2011). Firms participating in the global production network can learn new information and knowledge, which can lead to the increase of their innovativeness. Evidence from developing countries' industrial development shows that when firms are integrated into the global value chain, generally through the original equipment manufacturing (OEM) arrangement, they can learn to upgrade their products and production processes (Humphrey & Schmitz, 2002). The upgrading may come from the buyers' investment in strengthening technological capabilities of their suppliers to guarantee the supply of products that meet their requirements, or from the suppliers' own efforts to comply with international standards (Pietrobelli, & Rabellotti, 2011). Finally, investment in research and development (R&D) is regarded as the most robust factor of firm innovation (e.g. Dosi, 1988; Raymond & St-Pierre, 2010). R&D can serve as the most valuable input of innovation, and hence it has a direct positive impact on innovation

(Becheikh et al., 2006). Investment in R&D can also enhance firm's absorptive capacity which, in turn, augments the innovative capability of the firm (Cohen & Levinthal, 1990).

Based on the above literature, we can state the hypotheses about the effects of establishment's characteristics and resources on its product innovation as follows:

Hypothesis 3a – larger establishments tend to innovate more than smaller establishments as they can possess more resources needed for innovative activities.

Hypothesis 3b – establishments that export tends to innovate more than those that do not export, as they are under pressures to innovate and can learn from knowledge spillovers in the export market.

Hypothesis 3c – establishments that have foreign share tends to innovate more than those that do not have, as they are more likely to gain valuable knowledge from foreign investors.

Hypothesis 3d – establishments that produce under OEM arrangement are more innovative than those that do not, as OEM increases the chance that they can learn new knowledge from the global buyers.

Hypothesis 3e – establishments that invest in R&D tend to be more innovative than those that do not invest, as R&D helps to enhance their innovative and absorptive capacities.

3. RESEARCH METHODOLOGY

3.1 Data and Sample

A sample of 3,200 establishments was randomly drawn from the Department of Industrial Works' (DIW) list of 8,985 registered food processing establishments; this is an establishment-level data covering the whole population of food manufacturing establishments of all sizes in all provinces of Thailand. The sample establishments fall into six subsectors including: (1) processing and preserving of meat (ISIC101); (2) processing and preserving of fish, crustaceans and molluscs (ISIC102); (3) processing and preserving of fruit and vegetables (ISIC103); (4) manufacture of vegetable and animal oils and fats (ISIC104); (5) dairy products (ISIC105); (6) other food products (ISIC107). Data were collected during January-March 2016 using a questionnaire-based postal survey. A draft questionnaire was first developed and sent to five experts in the field of agricultural economics, industrial management, innovation studies, and business administration for their comments. A revision was made, and finalized questionnaires were sent by post to sample establishments with a cover letter requesting the senior manager or owner of the establishment to complete it. Of the 3,200 sample establishments, 299 responded to the survey, accounting for a response rate of 9.3%. The subsectoral distribution of 299 respondent establishments is as follows: ISIC101 = 47(15.7%); ISIC102 = 27(9.0%);

ISIC103 = 31(10.4%); ISIC104 = 62(20.7%); ISIC105 = 19(6.4%); and ISIC107 = 113(37.8). This pattern roughly reflects the distribution in the establishment population with the highest representation of ISIC107(48.3%) and lowest representation of ISIC105(4.5%). The size distribution of respondent establishments are 200(67.2%), 65(21.9%), and 33(10.9%) for small (S), medium (M), and large (L) enterprises, respectively[4]; this roughly reflects the size structure of the food industry as a whole in which the vast majority of establishments are SMEs (Saigosoom, 2012).

After screening the data and removing cases with missing values for dependent and independent variables, the number of observations reduced to 173 and 170 to be used respectively for the analysis of new product development (NPD) and significant product modification (PMOD).[5]

3.2 Variables

3.2.1 Dependent Variables

Innovation can take various forms such as product, process, organizational, and market innovations. This study focuses on product innovation. Based on previous empirical studies, factors explaining product innovation can be different depending on the degree of novelty of innovation. For instance, universities may contribute significantly to radical product innovation (e.g. development of a product that is new to the world) but not to minor modification of existing products (Todtling et al., 2009). This calls for the separation of the form of product innovation to be examined. In this study, I follow the practice in the previous studies (Nieto & Santamaria, 2007; Todtling et al., 2009) by separating the product innovation into two types based on its degree of novelty: (1) new product development (NPD); and (2) modification of existing products (PMOD). NPD captures a more radical form of innovation, while PMOD represents its incremental form. NPD is measured by counting the number of new products that a focal establishment has launched in the past three years. New products here capture the products that are new to the establishment, but not necessarily new to the industry or the world. Similarly, PMOD is measured by counting the number of existing products that were significantly modified in the past three years.[6] In the survey questionnaire, the managers/owners of the

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[4] Based on the definition given by the Office of SME Promotion, small, medium, and large enterprises are those employed 1–50, 51–200, and more than 200 workers, respectively.

[5] A reduction in the sample size may cause some concern regarding the efficiency of the estimates (Garson, 2015). However, by testing whether the missing satisfy the Missing Completely at Random (MCAR) rule, the Little's test for MCAR was not significant; this indicates that the data are missing completely at random and that the analysis that follows should not suffer considerably the problem associated with sample size reduction.

[6] Following the Oslo Manual (OECD, 1992), the data on NPD and PMOD were obtained by asking respondents two questions: (1) during the past three years, did your establishment introduce new products? (No/Yes, how many?); (2) during the past three years, did your establishment introduce significantly modified products? (No/Yes, how many?)

food processing establishments were given a clear explanation on what defines NPD and PMOD. NPD was described as the development of new product line, and be a product that the focal establishment had never produced before, while PMOD described as a significant extension of the product line, not just a marginal extension. This clarification is to avoid confusion that may result in the counting of marginal extension of existing product lines as NPD or PMOD. Of 173 sample establishments for NPD, 71 (41%) had at least one new product, while 102 (59%) had no NPD, resulting in a significant proportion of zeros in this sample. Similarly, of 170 sample establishments for PMOD, only 68 (40%) had at least one significantly modified product, while 102 (60%) had zero PMOD.

3.2.2 Independent Variables

Based on a review of the literature, independent variables in this study are divided into three groups. The first group represents an industrial cluster's context where food processing establishments operate. An industrial cluster in this study is defined as a geographical boundary of 150 kilometers from a focal establishment.[7] Variables in the first group capture the benefits of industrial clustering in terms of localization economies and competitive pressure. These variables are labor market pooling (*LABOR*), supplier concentration (*SUPCON*), knowledge spillovers (*KNSPIL*), and number of a focal establishment's business rivals (*RIVAL*) in the cluster. Theoretically, these variables capture the cluster context in which establishments are embedded and from which benefits can be drawn involuntarily only by being located in the cluster. Variables *LABOR*, *SUPCON*, and *KNSPIL* are measured by the 11-point Likert-scale questions, asking managers/owners' perception of the conditions in the industrial cluster where the establishment is located (0 = disagree, 10 = fully agree). *LABOR* and *KNSPIL* are constructed from a set of coherent questions. Variable *SUPCON* is derived from one question concerning the availability of raw material and intermediate input suppliers. Variable *RIVAL* is measured directly by asking the manager/owner to give the number of their potential competitors within the boundary of 150 km from their establishment. The questions used to construct each of these variables are provided in the appendix 1. These questions were derived from both theoretical and empirical literature reviewed. For example, there are three questions concerning the labor market pooling: (1) cluster has a large labor pool; (2) it is easy to find labor with skills that the establishment needs; and (3) labor mobility in the cluster is high. These questions are drawn from the literature that stresses the key characteristics of clusters as to include large labor market, ease of finding specialized labor, and high labor mobility (e.g. Krugman, 1991; Saxenian, 1994). The questions used to construct other variables in this group are drawn in a similar fashion. For variables that are constructed by multiple questions, the Cronbach's alpha statistic was used to test for their internal consistency.

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[7] The survey questionnaire asked the manager/owner of the establishment to think of the industrial cluster as an area within a radius of 150 kilometers from their establishment.

The second group of variables measures the knowledge interaction between food processing establishments and knowledge actors in the cluster including suppliers, customers, business service firms, universities, and government agencies. Knowledge interaction in this study is defined in terms of (1) the frequency that an establishment contacts with the knowledge actor and (2) the extent to which a focal establishment acquire knowledge and information from the knowledge actor.[8] The idea is that not only does the frequency of interaction but also the importance of each interaction regarding knowledge transfer and information exchange that matter for innovation. In the survey, the respondents were asked to rate (on 11-point Likert scale) for each knowledge actor the following two items: (1) the frequency of contact with the knowledge actor (0 = not at all; 10 = highest); and (2) the extent to which they acquire knowledge and information from the knowledge actor (0 = not at all; 10 = highest) in the past three years. Then, variables that capture the knowledge interaction between the establishment and each knowledge actor were constructed by taking the average score of these two items. The *Cronbach's alpha* statistic was calculated to check whether these two items (for each knowledge actor) exhibit a high internal consistency. From this process, six knowledge interaction variables were derived. These variables are the establishment's knowledge interactions with suppliers (*SUPP*), customers (*CUST*), vertical knowledge interaction with suppliers and customers (*VERTI*),[9] business service firms (*BUSER*), universities and research organizations (*UNIV*), and governmental agencies (*GOV*). Knowledge interaction variables are built on the theoretical and empirical literature that argues for the importance of localized network and collaboration between firms and various organizations within the industrial cluster (see Section 2.2).

The last group of variables represents the characteristics and resources of the establishment which are regarded as control variables in this study. These variables are establishment size (*SIZE*), foreign investment (*FORGN*), export (*EXPO*), production for foreign buyers under OEM arrangement (*OEM*), and investment in R&D (*R&D*). Variables *FORGN*, *EXPO*, *OEM*, and *R&D* are constructed as a binary dummy variable: *FORGN* = 1 if an establishment has foreign investment share, and 0 otherwise; *EXPO* = 1 if an establishment exports its products and 0 otherwise; *OEM* = 1 if an establishment produces for foreign buyers under OEM arrangement, and 0 otherwise; and R&D = 1 if an establishment invests in R&D, and 0 otherwise. Variable *SIZE* is measured by the number of full-time employees of the establishment. Also, five industry dummy variables are included to capture the specific sub-sector effect on establishments' ability to innovate, with *SEC01* being a base sector (see Appendix 1).

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8 Note that knowledge interaction in this study is defined in a broad term. No difference is made between formal, market-based, and informal interactions. This is to capture a broad range of interactions that may benefit, directly or indirectly, establishments in terms of information and knowledge used for enhancing their innovative capabilities.

9 Knowledge interactions with suppliers and customers are pooled together to avoid the problem of multicollinearity.

3.3 Estimation Method

In this study, dependent variables are a discrete count of NPD and PMOD with two distinctive characteristics: (1) non-negative integers; and (2) a significant proportion of zeros. With these features, the application of standard linear statistical methods, such as Ordinary Least Square (OLS), are no longer appropriate and may result in inefficient and unreliable estimators (Long, 1997). There are several statistical methods specifically designed to deal with count dependent variables. Relevant methods are the Poisson Regression (PR) and Negative Binomial Regression (NBR). In the PR model, the probability of a count is determined by a Poisson distribution, where the mean of distribution is a function of independent variables. The PR model is based on a restrictive assumption of equality of conditional mean and variance. In other words, it is not robust in the case where conditional mean and variance are not equal. The NBR is an alternative method to deal with such situation. The NBR is not based on a mean-variance equality assumption; hence, it is more robust in the case where variance exceeds the mean, which is likely to observe in practice due to the unobserved heterogeneity in the sample (Long, 1997). Therefore, in this study, I used the NBR to analyze the relationship between NPD and PMOD and a set of independent variables. The dispersion parameter (α) is also produced to check whether the conditional mean and variance are equal and to justify the application of NBR.

4. RESULTS AND DISCUSSION

The descriptive statistics summarizing the characteristics of sample establishments are shown in Appendix 2. As can be seen, the average sizes (number of employees) of the NPD and PMOD samples are 134 and 137, respectively. The proportion of establishments with the foreign share is rather small – 7.5% and 6.5% for NPD and PMOD samples, respectively. About 38% of establishments in these two samples export their products, and almost 18% of them involves in OEM production. Interestingly, more than one-fourth of establishments in the samples invest in R&D. Lastly, the sectoral composition of these two samples mirrors the structure of the food processing industry as a whole in which the subsector ISIC107 is the largest subsector and ISIC105 is the smallest one.

The binary correlations between each pair of variables were examined. Notably, there is only a correlation between variables SUPP and CUST that is very high and has potential to cause the multicollinearity problem ($r > 0.75$).[10] To solve this problem, I estimated them in separate model specifications. I also combined them and created a new variable – VERTI – which captures the knowledge interaction between the focal establishment and its suppliers and customers and estimated this new variable in the other specification.

Tables 1 and 2 report the NBR results for NPD and PMOD models, respectively. In each model, four specifications were run. Specification 1 serves as a base specification, where only establishment

[10] To save space, the binary correlations are not reported here, but can be provided upon request.

characteristic variables are included. Specifications 2, 3, and 4 include all variables of interest with variables SUPP, CUST, and VERTI separately estimated in each of these specifications. The first thing to note is the statistical significance of alpha parameter, which indicates the over-dispersion in the data and justifies the preference of the NBR over the PR. In each specification, the coefficients of independent variables are simultaneously unequal to zero as indicated by a statistical significance of *LR* Chi^2 statistic. Independent variables seem to explain the variation in NPD better than PMOD models, as the value of *Pseudo* R^2 is higher for the former. The inclusion of variables capturing localization economies and knowledge interaction improves the goodness of fit of the models fairly well, as can be seen from the increase in *Pseudo* R^2 of specification 2-4 from that of specification 1.

For NPD results (Table 1), it is found that OEM and R&D are only establishment characteristic variables that have strong, robust, and statistically significant effects on NPD. The coefficients of OEM are positive and vary between 1.180 and 1.330 with statistical significance at 1% level in four specifications, indicating that food processing establishments that produce for foreign buyers via OEM arrangement are more likely than those that do not to develop new products. This is consistent with the theory of global value chain which claims that insertion into the chain can provide a good opportunity for local enterprises in developing countries to upgrade their innovative capabilities (Humphrey & Schmitz, 2002). Coefficients of R&D variable are also positive ranging between 1.774 and 1.831 with 1% statistical significance level in all specifications. Thus, establishments that make efforts to invest in internal R&D are more likely to develop new products. This result is consistent with the theoretical prediction that investment in R&D enhances both absorptive and innovative capacities (Cohen & Levinthal, 1990; Becheikh et al., 2006). Among five sub-sector dummy variables, only ISIC107 has positive and significant effects. This sub-sector involves the production of such products as snacks, condiments, instant and ready-to-eat foods, which are subject to highly changing demands and thus are more likely than other sub-sectors to develop new products. Variables SIZE, FORGN, and EXPO are not statistically significant in any specification. Thus, being a large establishment, having foreign investment share, or exporting products do not improve the likelihood to develop new products.

In the group of three variables that capture localization economies, only LABOR has a positive and significant effect on NPD, while KNSPIL has a significantly negative effect. The positive and significant coefficient of LABOR gives the interpretation that the cluster that has a large local labor market with sufficient skills that meet food processing establishments' demand and with high mobility of labor force can benefit the establishment's new product development. This finding confirms the importance of workers as a carrier of the knowledge and skills necessary for NPD process (Saxenian, 1994). In contrast, the negative coefficient of KNSPIL may give an interpretation in terms of knowledge leakage: when knowledge flows freely and quickly, it may reduce innovative activities as establishments may adopt an opportunistic strategy to acquire knowledge produced by others rather than invest in knowledge creation themselves.

The coefficients of RIVAL are positive and statistically significant, meaning that establishments will tend to develop new products when they perceive that they have many rivals in the industrial cluster where they operate. Based on Porter's (1998) explanation, co-location with a large number of business rivals may pressure establishments to innovate. Also, establishments can use information about their rivals as a benchmark of their relative position against rivals which allow them to determine their innovation strategies (Dickson, 1992).

Of four variables that capture knowledge interaction, only UNIV has the positive and significant effect on NPD. Thus, knowledge interaction with universities and public research institutes in the cluster increases the possibility that establishments will develop new products, while interactions with suppliers and customers (i.e. vertical knowledge interaction), business service companies, and government agencies do not provide establishments with that benefit.

Table 1: NBR results for new product development (NPD)

	Spec.1		Spec.2		Spec.3		Spec.4	
	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
Const.	–1.383[a]	.435	–1.316[b]	.590	–1.314[b]	.596	–1.304[b]	.596
SIZE	–2.0E-04	2.6E-04	–2.3E-04	2.6E-04	–2.4E-04	2.6E-04	–2.3E-04	2.6E-04
EXPO	–.235	.347	–.408	.350	–.432	.356	–.440	.356
FORGN	.357	.501	.620	.483	.673	.472	.641	.481
OEM	1.204[a]	.365	1.180[a]	.340	1.211[a]	.345	1.226[a]	.347
R&D	1.802[a]	.332	1.831[a]	.379	1.746[a]	.376	1.774[a]	.379
ISIC102	.989[c]	.556	.789	.581	.876	.595	.867	.592
ISIC103	.745	.650	.947	.647	1.031	.659	1.031	.658
ISIC104	–.528	.554	–.353	.610	–.332	.609	–.296	.616
ISIC105	.891	.620	.492	.666	.413	.652	.467	.661
ISIC107	1.427[a]	.455	1.437[a]	.498	1.483[a]	.511	1.487[a]	.510
LABOR			.259[b]	.105	.280[b]	.110	.282[b]	.110
SUPCON			–.131	.088	–.154[c]	.088	–.147	.089
KNSPIL			–.242[b]	.102	–.238[b]	.101	–.242[b]	.102
RIVAL			.012[b]	.005	.012[b]	.005	.012[b]	.005
SUPP			–.040	.073				
CUST					–.043	.078		

Table 1: NBR results for new product development (NPD) (Cont.)

	Spec.1		Spec.2		Spec.3		Spec.4	
	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
VERTI							–.056	.085
BUSER			.067	.086	.062	.087	.067	.088
UNIV			.196b	.082	.215[b]	.087	.215[b]	.087
GOV			–.128	.083	–.132	.086	–.133	.085
LR Chi^2(df)	77.00(10)[a]		99.21(18)[a]		98.20(18)[a]		98.34(18)[a]	
Pseudo R^2	0.134		0.171		0.171		0.171	
Alpha(SE)	1.679(.354)[a]		1.323(.287)[a]		1.341(.292)[a]		1.344(.292)[a]	
Obs.	173		173		173		173	

Note: Superscripts a, b, and c denote statistical significance at 1%, 5%, and 10% levels, respectively.
Source: Author

In the PMOD model (Table 2), some differences and similarities with NPD model are observed. For variables representing establishment characteristics, SIZE, FOREGN, and EXPO are still not significant. Hence, larger establishments, establishments with foreign share, and those that export their product do not stand a better chance to introduce NPD and PMOD. These results lead to the rejection of Hypotheses 3a, 3b, and 3c above. OEM has lost its significance, which means that Thai food processing establishments benefit from OEM only in terms of new product development, but not product modification. A possible interpretation is that product modification does not require a high degree of technical knowledge, so establishments do not need to rely on foreign buyers for knowledge to achieve it. These finding partially support hypothesis 3d in that OEM matters for NPD, but not PMOD. As similar to the NPD model, the effect of R&D in the PMOD model is positive and significant; this indicates that R&D is necessary for both product development and modification. Thus, Hypothesis 3e is fully supported as R&D is important for both NPD and PMOD. Sub-sector dummies do not have any significant effect on establishments' product modification, particularly when the effects of all independent variables are accounted for (specification 4).

In four contextual variables that capture localization economies and local competition, only LABOR has a positive and significant effect. Thus, it can be said that the cluster's labor market is not only conducive to new product development, but also to product improvement. These findings confirm Hypothesis 1a that the cluster's labor market pool plays a significant role in food establishments' product innovation (both NPD and PMOD). On the other hand, Hypothesis 1b is not confirmed as the supplier concentration (SUPCON) is not significant for both NPD and PMOD. In the case of KNSPIL, it turns out that the effect of this variable is still negative in the PMOD model (as in the NPD model), but such effect is not statistically significant. This finding runs counter Hypothesis 1c and gives the meaning that localized knowledge spillovers tend to undermine the product innovation of food processing establishments in the cluster. Unlike the NPD model, variable RIVAL is not statistically significant in the PMOD model. As this variable is measured by the number of rivals that managers/owners perceive, the result may give the interpretation in terms of the innovative effort that they tend to make in relation to the degree of technological sophistication required for product innovation. In the case of NPD, which requires more technical knowledge, strong competitive pressures may be necessary to drive the effort to achieve it. In contrast, PMOD requires less technical sophistication and hence less effort can be made to achieve it. It is possible to conclude that Hypothesis 1d is partially confirmed as RIVAL is only significant for NPD but not PMOD.

For knowledge interaction variables, interesting results are obtained. Variable UNIV, which has a positive effect on NPD, turn out to be insignificant on PMOD. This result can be interpreted that knowledge acquired from universities and research institutes is only necessary for a more radical type of innovation (i.e. NPD). For the incremental type of innovation (i.e. PMOD), which requires less advanced technical knowledge, there is no need to rely on these institutions to achieve it. This result partially supports Hypothesis 2d in that establishments' interactions with their collocated universities and research institutes only lead to NPD but not PMOD. The coefficient of GOV is negative and statistically significant, indicating that the more establishments interact with their collocated governmental agencies the less likely they are to modify their products. Thus, it can be argued that the role of governmental agencies in the process of establishment's product modification tends to be restrictive rather than supportive. The findings that GOV is insignificant in the NPD model and that it is significantly negative in the PMOD model run counter Hypothesis 2e and reveal that governmental agencies in the cluster are not important sources of knowledge to be used by food processing establishments for their product development and improvement. The remaining variables – SUPP, CUST, VERTI and BUSERV – are not significant, as similar to the results obtained in the NPD model. Thus, in this study, Hypotheses 2a, 2b, and 2c are not confirmed; and suppliers, customers, and business service providers in the cluster are unlikely to be important sources of knowledge for food processing establishments' product innovation.

Table 2: NBR results for product modification (PMOD)

	Spec.1		Spec.2		Spec.3		Spec.4	
	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
Const.	.359	.390	–.099	.657	–.030	.667	–.106	.660
SIZE	1.3E-04	5.0E-04	1.3E-04	4.7E-04	1.4E-04	4.6E-04	1.6E-04	4.7E-04
EXPO	–.0122	.375	–.449	.424	–.355	.432	–.424	.428
FORGN	.041	.725	.104	.705	.008	.714	.091	.713
OEM	–.085	.455	.346	.484	.410	.485	.350	.487
R&D	1.394[a]	.388	1.348[a]	.494	1.357[a]	.503	1.379[a]	.499
ISIC102	–.324	.690	.221	.802	.408	.809	.257	.807
ISIC103	–.083	.642	.342	.688	.582	.695	.412	.694
ISIC104	–1.367	.550	–1.137	.677	–.880	.674	–1.047	.678
ISIC105	–1.72	.766	–1.649	.875	–1.387	.853	–1.484c	.862
ISIC107	–.501	.469	–.103	.590	.152	.601	–.018	.598
LABOR			.272b	.133	.311b	.137	.280b	.135
SUPCON			–.153	.115	–.130	.111	–.128	.113
KNSPIL			–.046	.127	–.087	.127	–.064	.128
RIVAL			–.004	.007	–.006	.007	–.004	.007
SUPP			.064	.077				
CUST					–.085	.099		
VERTI							.013	.095
BUSER			.069	.112	.151	.120	.096	.117
UNIV			.078	.102	.073	.101	.064	.102
GOV			–.224b	.104	–.210b	.101	–.216b	.103
LR $Chi^2(df)$	30.34(10)[a]		41.06(18)[a]		41.21(18)[a]		40.50(18)[a]	
Pseudo R^2	0.001		0.078		0.078		0.078	
Alpha(SE)	2.686(.515)[a]		2.436(.472)[a]		2.426(.470)[a]		2.433(.471)[a]	
Obs.	170		170		170		170	

Note: Superscripts a, b, and c denote statistical significance at 1%, 5%, and 10% levels, respectively.

Source: Author

Based on the above findings, some important points can be highlighted with policy implications. First, in this sample, some characteristics and resources of establishments can be regarded as more important than others. Specifically, investment in R&D and producing for foreign buyers under OEM arrangement are more conducive to product innovation than establishment size, foreign investment, and export. Among all establishment characteristics examined in this study, R&D serves as the best predictor of product innovation. Knowledge derived from R&D process is necessary to achieve both rapid and incremental innovation. Theoretically, R&D enhances internal capabilities to produce, assimilate, and utilize knowledge. However, as widely known that food processing establishments in Thailand are relatively inactive in R&D investment, policies to promote innovation in food processing industry should aim at lowering costs as well as strengthening firms' incentives to invest in R&D. OEM can also help decrease the costs of innovation. Establishments that produce for foreign buyers under OEM arrangement can learn from their buyers. Thus, a policy that facilitates the insertion of indigenous firms into the global value chain (e.g. liberalization of trade and investment) should be promoted. Note that export alone may not yield innovative outcomes if the connection with the buyer is not strong enough to open opportunities for suppliers to learn from their buyers.

Second, industrial clusters characterized by a large pool of specialized and highly mobile workforce and by competitive pressures can be regarded as favorable context for establishments' product innovation, though the competitive force is only significant for NPD. In this regard, effective regional policies and initiatives that aim to increase the supply of specialized workforce (e.g. those carried out via training and education systems) and to facilitate market competition should be promoted.

Third, this study reveals the important role that local universities and research institutes can play in helping food processing establishments develop their new products. Some earlier studies have highlighted the weakness of Thai universities in the context of university-industry linkages and national innovation system (Schiller, 2006; Doner, Intarakumnerd, & Richie, 2013). However, to my knowledge, there is no study to evaluate how interaction and exchange of knowledge with local universities and research institutes can help the establishments increase their innovative capability. The currrent study is the first to show that local universities and research institutes can still be expected to serve as important knowledge actors from which food processing establishments can learn. In fact, universities and research institutes not only can help establishments innovate *directly* by providing knowledge relevant for NPD, but also *indirectly* by producing a qualified workforce that creates a local pool of skilled labor. In contrast, the role of governmental agencies is not significant or even limits the product innovation in the food processing industry. To date, it seems that the Thai government has placed a greater role in the (local) governmental agencies to drive industrial cluster policies/initiatives. However, as shown in this study, those agencies do not prove to be helpful. Thus, the government should re-evaluate the role played by their agencies and adjust them in the way that is more conducive to promoting innovation.

Fourth, as long as NPD is concerned, this study implies the complementarity of knowledge which is generated internally and acquired externally. Food processing establishments that are more likely to be successful in developing new products are those that make efforts in creating knowledge (in this case, by investing in R&D) and in searching knowledge from external knowledge sources available in their locality (in this case, local universities and research institutes).

Fifth, the insignificant results for knowledge interaction with customers in both NPD and PRMOD models are rather surprising, given that most Thai food processing establishments are OEM manufacturers. Customers who seem play a significant role in product innovation are foreign customers, as shown by a significantly positive effect of OEM on NPD. This result gives an implication that not all interactions between the establishments and their customers are conducive to product innovation; only interaction with foreign buyers under OEM arrangement that enhances establishment's capability to develop new products.

Finally, the results from this study provide policy implication that the government's cluster-based policies/initiatives for the promotion of product innovation in Thai food processing industry should take into account both contextual as well as knowledge interaction factors. Creating sound industrial cluster environment should be implemented in parallel with providing sufficient incentives that encourage the interactive learning between establishments and some key knowledge actors.

5. CONCLUSION

This study has examined the factors that explain the product innovation in Thailand's food processing industry. I have attempted to fill two notable knowledge gaps in the literature. The first gap is that existing studies about innovations in the Thai food industry have not yet investigated the effect of industrial clustering on innovations. The second knowledge gap is that there has been a long unresolved debate in the industrial cluster literature on what cluster mechanisms that matter for firms' innovation – *localization economies or knowledge interaction?* In this study, I have extended the analytical framework to account for the effects of localization economies and knowledge interaction variables to gain a better understanding of how these mechanisms help to promote food processing establishments' product innovation. Data from the survey of food processing establishments in Thailand was analyzed using the negative binomial regression of count dependent variables, i.e. numbers of new products (NPD) and significantly modified products (PMOD). NPD is considered as a radical form of product innovation, while PMOD is considered as an incremental form.

Important results are as follows. First, investing in R&D and producing for foreign buyers under OEM arrangement are significant for product innovation. Investing in R&D generates knowledge that can be used for both radical and incremental product innovations, while OEM is only necessary for radical product innovation. Second, localization economies in terms of labor market pooling are relevant for establishments' product innovation. Industrial clusters characterized by a large pool of labor tend to be conducive to both types of innovation. Also, the competitive pressure in the cluster exerts the positive influence on establishments' NPD. Establishments that are surrounded by many competitors are inclined to develop new products in order to remain competitive. Third, knowledge interaction with universities and research institutes located in the industrial cluster is helpful for establishments' NPD, while interactions with suppliers, customers, and governmental agencies are not found to be relevant. Based on these results, it can be suggested that cluster-based policies and initiatives to promote product innovation in the Thai food industry should aim to create the cluster environment that is conducive to enhancing establishments' innovative capabilities (e.g. promoting competition and improving labor market condition). At the same time, incentives to promote knowledge interaction between establishments and their co-located knowledge actors (especially, universities and research institutes) should also be provided.

This study has some limitations that should be addressed by the future research. First, in this study, I only focused on knowledge interaction in the industrial cluster which is defined as a spatial boundary within 150 km radius from a focal establishment. In reality, knowledge interaction can take place in broader geographical scope, e.g. at the national and global levels. Future research can further examine the effects of knowledge interaction beyond the industrial cluster. Second, knowledge flow may not only exist in the interaction between a focal establishment and external knowledge sources but also between knowledge actors within the establishment itself. Apparently, this study has found that internal R&D efforts significantly affect both NPD and PMOD. However, it has not examined how R&D efforts are managed and how knowledge from various divisions or individuals within the establishment is combined to transform R&D activities into innovative outcomes. Future study should examine the contribution of (as well as complementarity between) internal and external knowledge interactions on the establishment's' innovation performance.

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Appendix

Appendix 1: Summary of independent variable construction and theoretical foundation

Var.	Construction/measurement
LABOR	Composite index constructed by taking the average of three 11-piont Likert-scale questions (0–1; 0 = disagree, 10 = fully agree): (1) Cluster has a large labor pool; (2) It is easy to find labor with skills that the establishment needs; (3) Labor mobility in cluster is high. (Cronbach's $\alpha = 0.792$)
SUPCON	One 11-point Likert-scale question (0–10; 0 = disagree, 10 = fully agree): There is a high agglomeration of intermediate input and raw material suppliers, and it is not difficult to find those suppliers.
KNSPIL	Composite index constructed by taking the average of five 11-piont Likert-scale questions (0–10; 0 = disagree, 10 = fully agree): (1) The is a high degree of interaction among managers/owners of establishments in the cluster; (2) Managers/owners of establishments always exchange knowledge and information; (3) Movement of skilled labors bring knowledge from one establishment to other establishments; (4) It is easy to find information about technologies and capacities of rivals; (5) When someone innovate or introduce new technologies, it will be soon widely known by others in the cluster. (Cronbach's $\alpha = 0.795$)
RIVAL	Number of competitors in industrial cluster perceived by the respondent
SUPP	Composite index constructed by taking the average of two 11-piont Likert-scale questions (0–10; 0 = not at all; 10 = highest): (1) the frequency that a focal establishment had contacted with its suppliers in the cluster in the past three years; (2) the extent to which the focal establishment acquire knowledge and information from suppliers in the past three years. (Cronbach's $\alpha = 0.735$)
CUST	Composite index constructed by taking the average of two 11-piont Likert-scale questions (0–10; 0 = not at all; 10 = highest): (1) the frequency that a focal establishment had contacted with its customers in the cluster in the past three years; (2) the extent to which the focal establishment acquire knowledge and information from customers in the past three years. (Cronbach's $\alpha = 0.761$)

Appendix 1: Summary of independent variable construction and theoretical foundation (Cont.)

Var.	Construction/measurement
VERTI	Composite index constructed by taking the average of four 11-piont Likert-scale questions (0–10; 0 = not at all; 10 = highest): (1) the frequency that a focal establishment had contacted with its suppliers in the cluster in the past three years; (2) the extent to which the focal establishment acquire knowledge and information from suppliers in the past three years; (3) the frequency that a focal establishment had contacted with its customers in the cluster in the past three years; (4) the extent to which the focal establishment acquire knowledge and information from customers in the past three years. (Cronbach's α = 0.866)
BUSER	Composite index constructed by taking the average of four 11-piont (0–10) Likert-scale questions (0 = not at all; 10 = highest): (1) the frequency that a focal establishment had contacted with business service firms in the cluster in the past three years; (2) the extent to which the focal establishment acquire knowledge and information from business service firms in the past three years. (Cronbach's α = 0.839)
UNIV	Composite index constructed by taking the average of four 11-piont (0–10) Likert-scale questions (0 = not at all; 10 = highest): (1) the frequency that a focal establishment had contacted with universities in the cluster in the past three years; (2) the extent to which the focal establishment acquire knowledge and information from universities in the past three years. (Cronbach's α = 0.886)
GOV	Composite index constructed by taking the average of four 11-piont (0–10) Likert-scale questions (0 = not at all; 10 = highest): (1) the frequency that a focal establishment had contacted with government agencies in the cluster in the past three years; (2) the extent to which the focal establishment acquire knowledge and information from government agencies in the past three years. (Cronbach's α = 0.842)
SIZE	Number of full-time employees
FORGN	Binary dummy variable: 1 = If the establishment has foreign investment share; 0 = otherwise.
EXPO	Binary dummy variable: 1 = If the establishment exports its products; 0 = otherwise.
OEM	Binary dummy variable: 1 = If the establishment produces for foreign buyers under OEM arrangement; 0 = otherwise.
R&D	Binary dummy variable: 1 = If establishment invests in R&D; 0 = otherwise.

Appendix 1: Summary of independent variable construction and theoretical foundation (Cont.)

Var.	Construction/measurement
ISIC101	Binary dummy variable: 1 = Establishment is in the processing and preserving of meat sub-sector; 0 = otherwise
ISIC102	Binary dummy variable: 1 = Establishment is in the processing and preserving of fish, crustaceans and molluscs sub-sector; 0 = otherwise
ISIC103	Binary dummy variable: 1 = Establishment is in the processing and preserving of fruit and vegetable sub-sector; 0 = otherwise
ISIC104	Binary dummy variable: 1 = Establishment is in the vegetable and animal oils and fats sub-sector; 0 = otherwise
ISIC105	Binary dummy variable: 1 = Establishment is in the dairy products sub-sector; 0 = otherwise
ISIC107	Binary dummy variable: = Establishment is in other food products sub-sector; 0 = otherwise

Appendix 2: Descriptive statistics for independent variables included in the regression models

	NPD Sample (n = 173)				PMOD Sample (n = 170)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
Continuous variables								
SIZE	1.00	1376.00	134.50	546.82	1.00	1376.00	137.23	539.32
LABOR	0.00	10.00	4.03	2.35	0.00	10.00	4.02	2.27
INPUT	0.00	10.00	4.82	2.40	0.00	10.00	4.81	2.30
KNOSPIL	0.00	10.00	3.76	2.56	0.00	10.00	3.76	2.42
RIVAL	0.00	710.00	17.33	62.59	0.00	500.00	14.27	37.87
SUPP	0.00	10.00	4.74	2.92	0.00	10.00	4.78	2.88
CUST	0.00	10.00	5.02	2.87	0.00	10.00	4.98	2.77
VERTI	0.00	10.00	4.86	2.74	0.00	10.00	4.88	2.67
BUSER	0.00	10.00	3.90	2.92	0.00	10.00	3.92	2.82
UNIV	0.00	10.00	2.65	2.86	0.00	10.00	2.64	2.80
GOV	0.00	10.00	3.66	2.68	0.00	10.00	3.66	2.62

	Yes	No	Yes	No
Binary dummy variables				
FORGN	13(7.5%)	160(92.5%)	11(6.5%)	159(93.5%)
EXPO	67(38.7%)	106(61.3%)	65(38.2%)	105(61.8%)
OEM	31(17.9%)	142(82.1%)	30(17.6%)	140(82.4%)
R&D	49(28.3%)	124(71.7%)	49(28.8%)	121(71.2%)
ISIC101	25(14.5%)	148(85.5%)	22(12.9%)	148(87.1%)
ISIC102	18(10.4%)	155(89.6%)	18(10.6%)	152(89.4%)
ISIC103	13(7.5%)	160(92.5%)	14(8.2%)	156(91.8%)
ISIC104	39(22.5%)	134(77.5%)	39(22.9%)	131(77.1%)
ISIC105	12(6.9%)	161(93.1%)	12(7.1%)	158(92.9%)
ISIC107	66(38.2%)	107(61.8%)	65(38.2%)	105(61.8%)

Source: Author's calculation